

Computational Fluid Dynamics study of an axial impeller often encountered in Anaerobic Digestion

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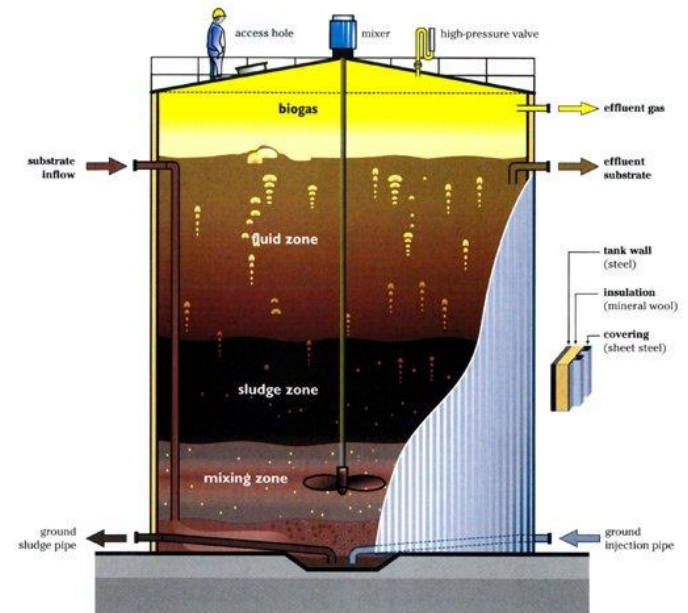
Model-based analysis and optimisation of bioprocesses

DEPARTMENT OF MATHEMATICAL MODELLING, STATISTICS AND BIOINFORMATICS



Anaerobic Digestion

- Anaerobic digestion (AD): Valorise biological sludges into CH_4
- Mixing in AD is an energy intensive operation in WWTP
- A better understanding is required to improve our knowledge in:
 - Design
 - Operation
 - Coupling with biochemical models
- Sludge is non-Newtonian (shear thinning) from 1-2% Total Solids



Breda (The Netherlands) digester $\approx 8935\text{m}^3$

PhD:

- Critical review on state-of-the-art of
 - CFD reactor modeling (validation)
 - Fluid properties
 - Link with biochemistry

Lab scale

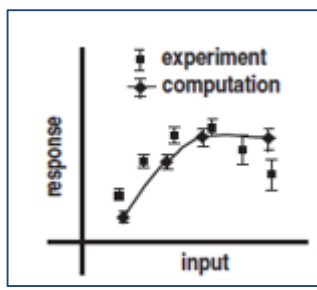
Full scale

- PIV data
- Validation metrics $u, k, \dot{\gamma}, \mu, \varepsilon$
 - Uncertainty quantification

- Measuring campaign
- Stratification
 - Sludge characterization

Calibration of rheological models

- Model validation:
- RANS vs PIV
 - Discussion on simplifying the model for up-scaling
 - Validation range

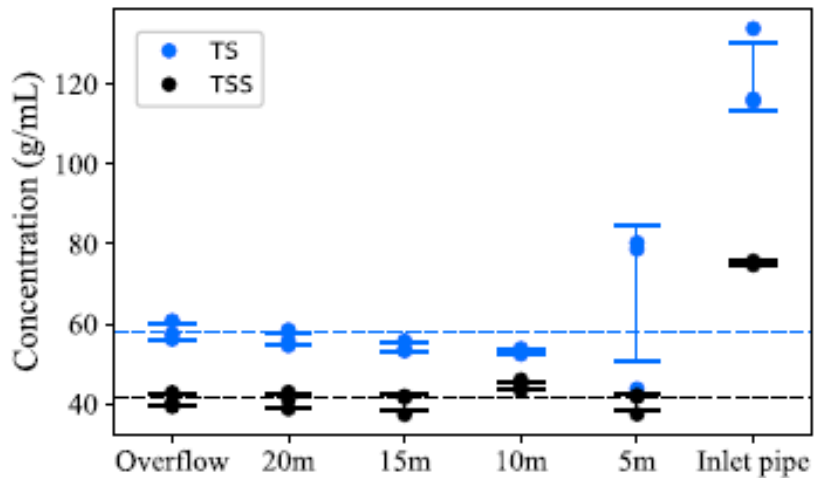


CFD model validated

- Full-scale CFD
- Mixing assessment
 - Compartmentalisation
 - Sensitivity analysis

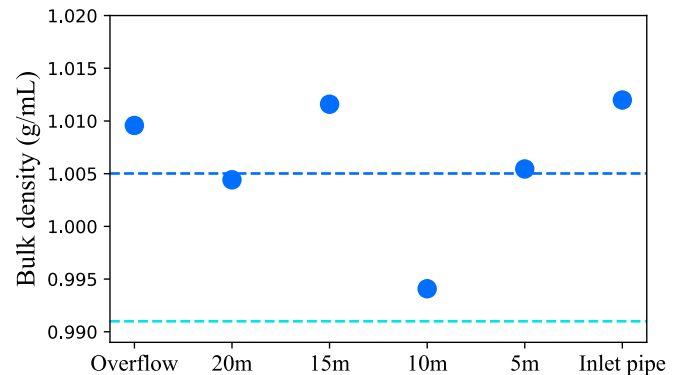
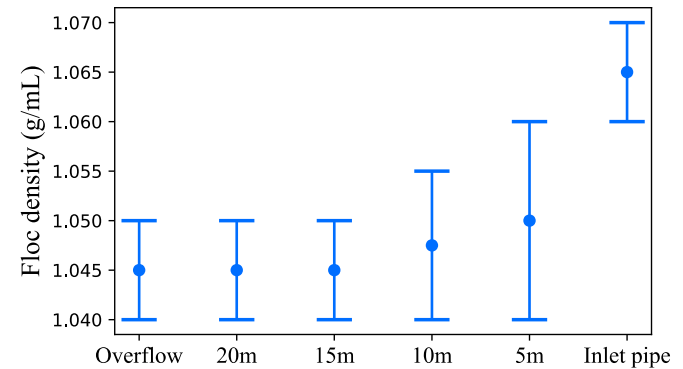
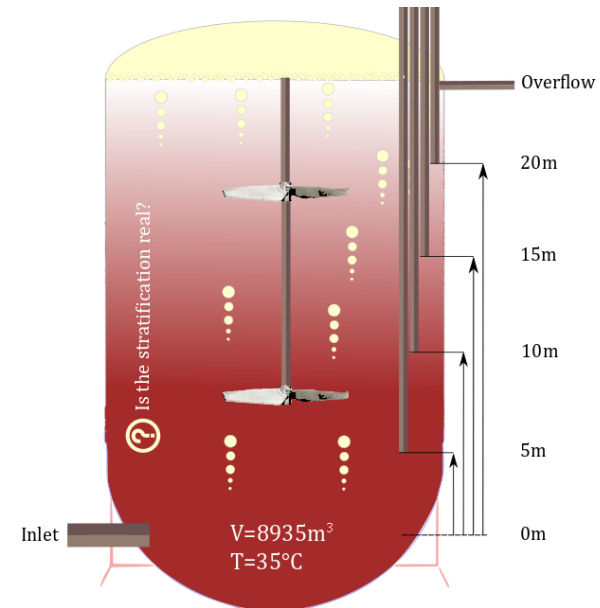
Full scale measuring campaign

Mild stratification from 10m downwards ($\approx 45\%$ reactor)



Sludge floc density (g/mL)

1.03 1.035 1.04 1.045 1.05 1.055 1.06 1.065 1.07

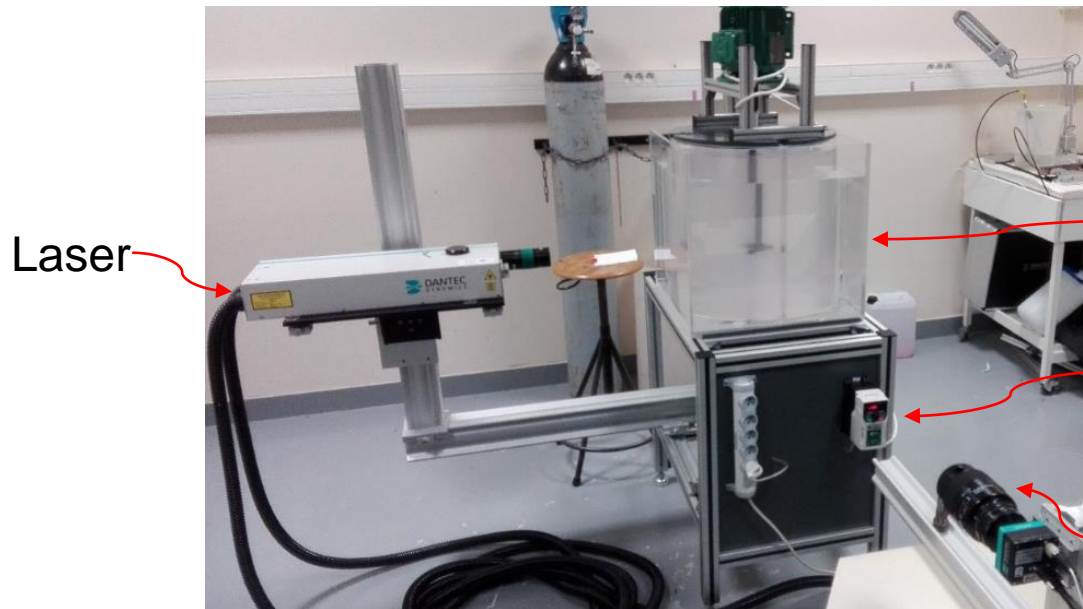


Particle Image Velocimetry (PIV)

Flow visualisation technique to obtain 2D velocity fields for validation purposes



Lightning A310
(Hydrofoil impeller)

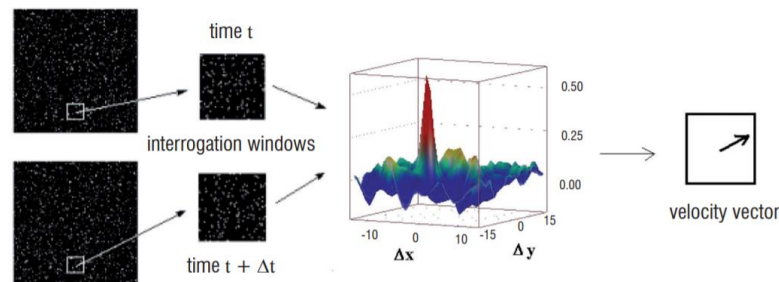


Laser

Scaled-down
stirring tank

100, 250, 500rpm

Camera

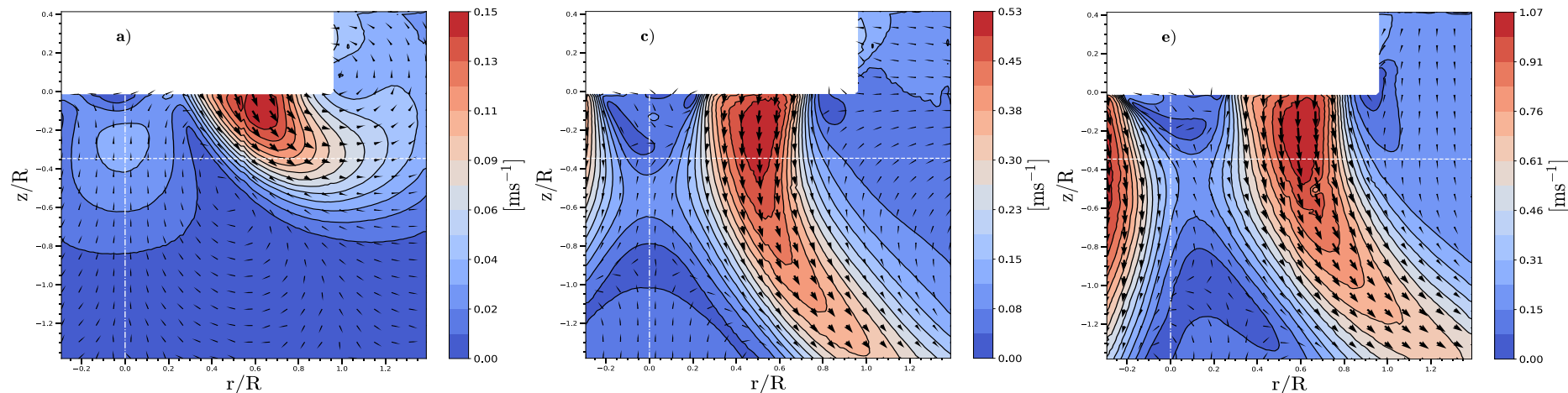


Mean velocity fields

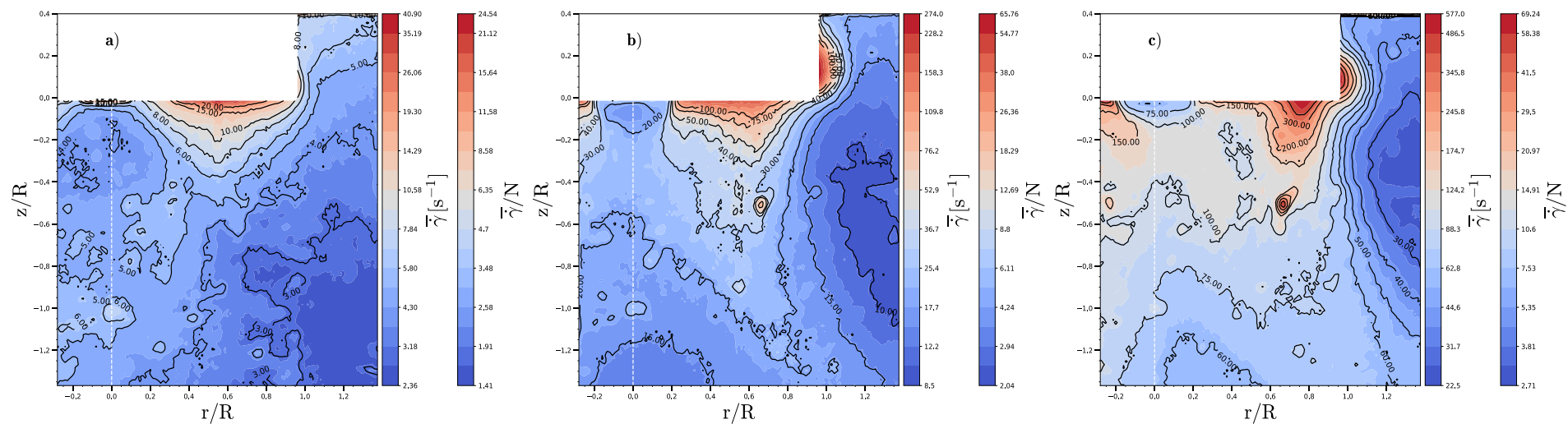
100 rpm

250 rpm

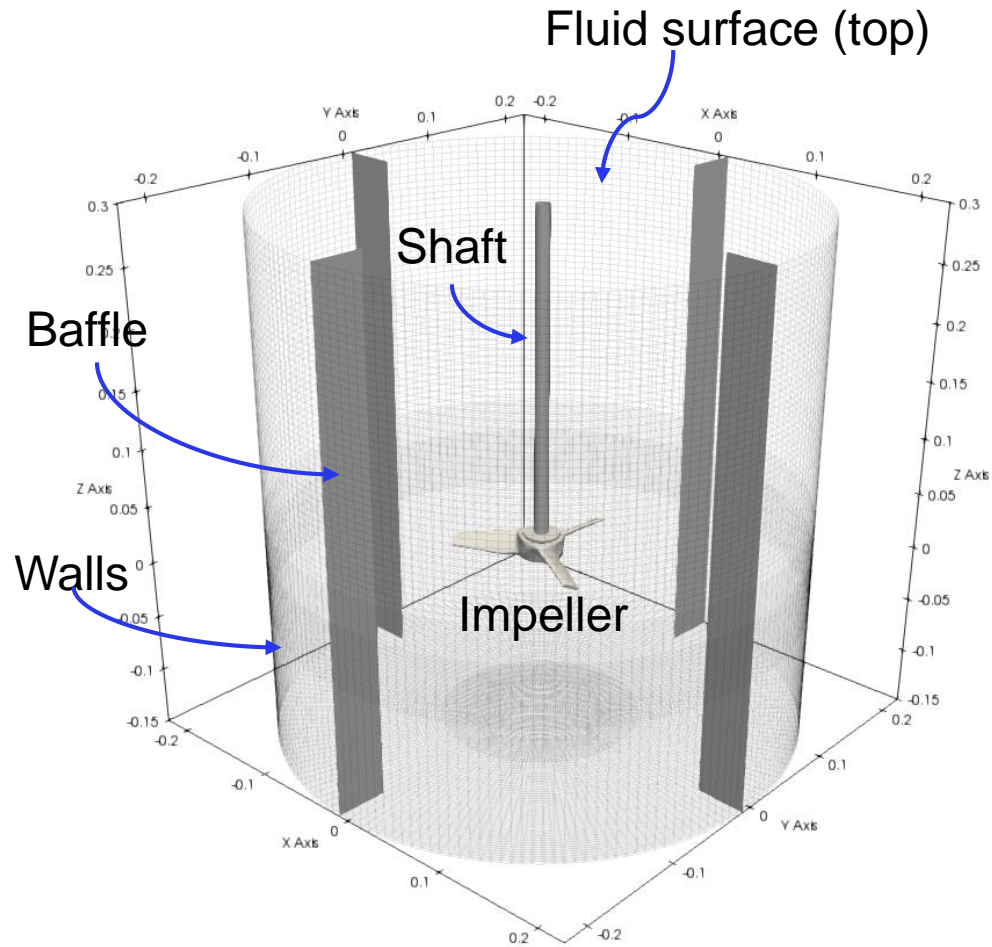
500 rpm



Mean shear rate fields

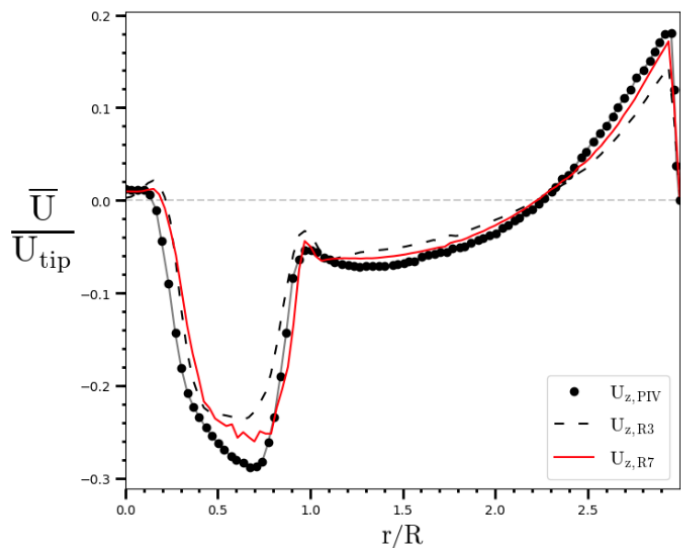


Computational Fluid Dynamics (CFD) model

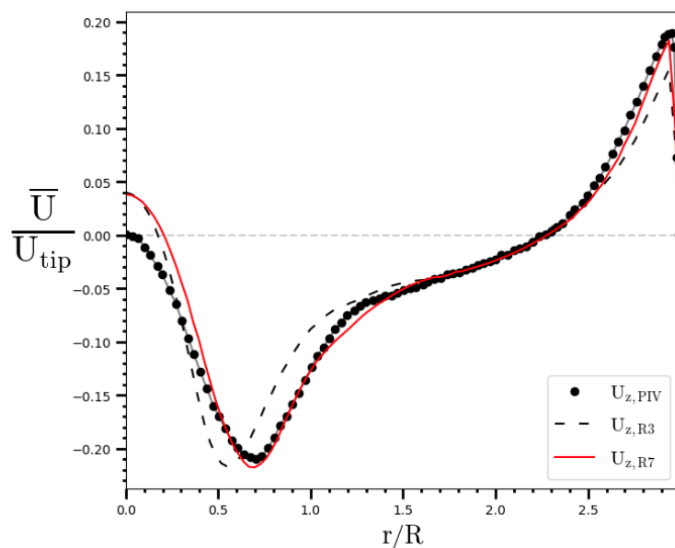


CFD VS PIV

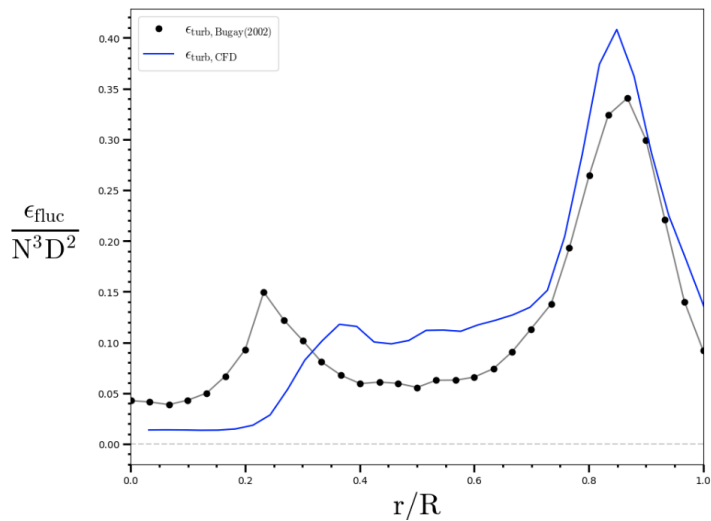
Mean Velocity Z=-5 mm



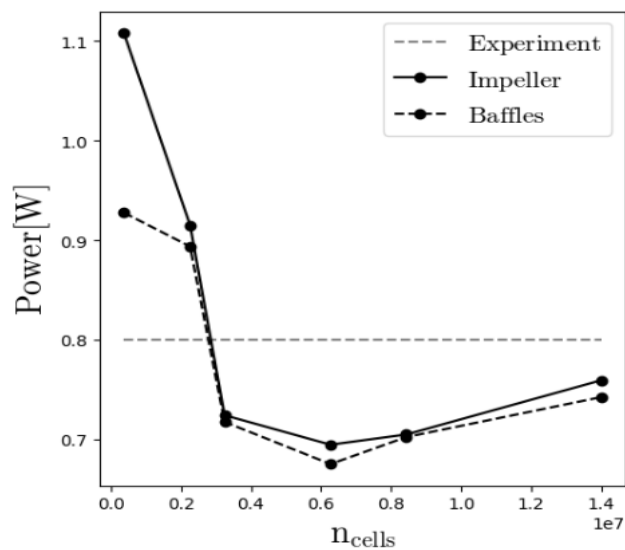
Z=-85 mm



Dissipation rate of TKE



Impeller power consumption



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model-based analysis and optimization of bioprocesses

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